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Exponential stability and periodic oscillatory of bi-directional associative memory neural network involving delays ☆

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Abstract

In this paper, bidirectional associative memory (BAM) neural network with delays is considered. By employing the inequality $b_{m+1}\prod_{k=1}^{m} b_k^{q_k} \leqslant 1/r\sum_{k=1}^{m} q_k b_k^r + (1/r)b_{m+1}^r$ ($b_{m+1} \geqslant 0$, $b_k \geqslant 0, q_k > 0$ with $1 + \sum_{k=1}^{m} q_k = r, k = 1, \ldots, m$), applying homotopic mapping and constructing a new Lyapunov functional method, we present some new criteria ensuring globally exponential stability and the existence of periodic oscillatory solution. These results are helpful to design globally exponential stability and periodic oscillatory for BAM neural network with delays.

Keywords: Exponential stability; Lyapunov functional; Bidirectional associative memory; Periodic oscillatory solution; Neural networks

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1. Introduction

Bidirectional associate memory (BAM) neural network, which was first introduced by Kosko [11,12]. It generalizes the traditional single layer neural networks model such as that of [9]. The BAM network is formed by neurons arranged in two layers, the X-layer and the Y-layer. The neurons in one layer are fully interconnected to the neurons in the other layer, while there are no interconnections among neurons in the same layer. Through iterations of forward and backward information flows between the two layer, it performs a two-way associative search for stored bipolar vector pairs. The class of networks has good application in pattern recognition, optimization problems, which has been one of the most active areas of research and has received much attention. One can refer to the articles [2,4–6,15,17,19,23,25] for detailed discussion on these aspects. Thus, from the viewpoint of application, the dynamical study for BAM neural network is quite important and significant, and cannot be replaced with the dynamical study for the traditional neural network such as Hopfield neural network and cellular neural network. Furthermore, in the analysis of dynamical BAM networks for parallel computation and optimization, to increase the rate of convergence to the equilibrium point of the network, it is necessary to ensure a desired exponential convergence rate of the network trajectories, starting from arbitrary initial states to the equilibrium point which corresponds to the optimal solution. From the viewpoint of mathematics and engineering, it is required that the equilibrium point of BAM network is globally exponential stability (GES). Moreover, the study on neural networks not only involve discussion of exponential stability, but also involve many dynamics behavior such as periodic oscillatory, bifurcation and chaos. The property of periodic oscillatory is of great interest. For example, the human brain has been in periodic oscillatory or chaos state. Thus, it is of fundamental significance to study periodic oscillatory phenomenon of neural networks. However, to the best of the author's knowledge, few authors discuss GES and periodic oscillatory for the BAM network with delays [4,5,7,13,14,16,17,20]. Moreover, in the previous results, many authors made use of the boundedness of the activation functions. Unfortunately, the assumption on the boundedness makes the results which are not applicable to some important engineering and physical problems, for example, this is the case of BAM for solving optimization problem in the presence of constraint (linear programming problems) [10].

Motivated by the above discussion, the objective of this paper is to study further globally exponential stability and the existence of periodic solution for the BAM network with delays. By employing the inequality $b_{m+1}\prod_{k=1}^{m} b_k^{q_k} \leqslant (1/r)\sum_{k=1}^{m} q_k b_k^r + (1/r)b_{m+1}^r$ ($b_{m+1} \geqslant 0, b_k \geqslant 0, q_k > 0$ with $1 + \sum_{k=1}^{m} q_k = r, k = 1, \ldots, m$) [18], applying homotopic mapping and constructing a new Lyapunov functional method, we give a family of new criteria ensuring GES and the existence of periodic oscillatory solution. In addition, the sufficient criteria obtained only need that the activation functions satisfy the Lipschitz conditions, and do not require that they are differentiable, bounded and monotone nondecreasing.